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SILURIAN AND DEVONIAN BIOSTRATIGRAPHY OF THE MELBOURNE TROUGH, VICTORIA

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Abstract: The biostratigraphy of the Silurian and Early Devonian of the Melbourne Trough is reviewed. A zonal scheme based on brachiopod assemblages is proposed, and includes the *Aegiria thomasi* Zone (early to mid Ludlow), *Notoparmella plentiensis* Zone (mid Ludlow to Pridoli), *Boucotia janaea* Zone (Lochkov), *Boucotia australis* Zone ('late' Lochkov to 'early' Pragian), and *Boucotia loyolensis* Zone ('early' to 'late' Pragian). These zones are correlated with established graptolite, conodont and dacryoconarid zones. The Siluro-Devonian boundary in southeastern Australia is based on shelly assemblages and is recognised by the abrupt appearance of the brachiopods *Schizophoria, Cymostrophia, Boucotia, Cyrtina* and *Cyrtinaella*.

The Melbourne Trough (Packham 1960; Fig. 1 herein) is a structural basin in the southwestern portion of the Lachlan Fold Belt (Cas *et al.* 1980). It contains Silurian and Lower Devonian marine rocks and is bounded by the submeridional Heathcote 'Axis' in the west and the Mt. Wellington 'Axis' in the east. The northern margin is covered by the Cainozoic Murray Basin succession; the southern margin is overlain by the Mesozoic and Cainozoic sediments of the Otway and Gippsland Basins.

A zonation of the Silurian and Devonian sequence is now possible on the basis of brachiopod faunas which may be integrated with standard graptolite and conodont zonations established elsewhere (Fig. 2, facing page 94). The zonal scheme is based on information from a large number of fossil localities within the Melbourne Trough (Garratt 1981a).

The brachiopod zonal scheme is divided into a number of assemblage zones here used in the sense of Hedberg (1976).

The Silurian and Devonian faunal zones of the Melbourne Trough are correlated with the graptolite zones of the British Silurian (Rickards 1976) and with the Upper Silurian and Lower Devonian of central Europe (Czechoslovakia and Poland) (Teller 1969, Jaeger 1959, 1979). Although much of the Victorian Upper Silurian-Lower Devonian lacks graptolites, correlation with the Bohemian stages is possible because *Monograptus aequabilis notoaequabilis* is found in Europe (Jaeger 1979) and Victoria (Jaeger *et al.* 1969). Further *M. thomasi* and the conodont *Eognathodus sulcatus sulcatus* occur in the same section in the eastern half of the Melbourne Trough and denote established Pragian zones (Jaeger 1979, Klapper & Zeigler 1979).

As yet graptolites are unknown from the Rhenish Devonian sequence and conodonts are uncommon, making it difficult to correlate with the sequence in south eastern Australia. Use of the terms Gedinnian, Lochkovian, Siegenian and Pragian follows that of Lütke (1979) and Jaeger (1979), rather than that of House (1979), Johnson (1975, 1979) and Norris (1979).

PREVIOUS CORRELATION SCHEMES IN THE MELBOURNE TROUGH

Early attempts at subdividing the Silurian-Devonian of the Melbourne Trough were carried out by trying to correlate the local sequence with Murchison's (1839) Silurian series of Britain. McCoy (1874-1888) subdivided the "Upper Silurian" series (=Silurian) of central Victoria into May Hill Sandstone (oldest), Wenlock and Ludlow, and gave very brief lists on the maps of Selwyn (1854-5), Aplin (1868), Taylor (1864a,b), Aplin & Taylor (1862), and Selwyn & Aplin (1858).

Gregory (1903) nominated local series for the Silurian of Victoria. He proposed a two-fold subdivision based on the palaeontological identifications of McCoy (1874-1888) and Etheridge (1878). The Melbourne Series (older) was based on faunas from Moonee Ponds Creek, Melbourne, and the younger Yering Series was based on collections made by Selwyn, Cresswell and Sweet from Yering, north of Lilydale.

Jutson (1908) and Chapman (1908) recognised an informal unit, "the Passage Beds", between the Yeringian and Melbournian, for a suite of fossils from beds low in the Merriang Syncline and also included those from Jutson's *"Spirifer"* band.

Chapman (1914, p. 212) thus interposed the Tanjilian Series to his (1908) scheme based on the *Panenka* Shales of the Tanjil River, Gippsland. He provided a full fossil list for the local Silurian series including *Aegiria thomasi* with most of the fossils given by him having been reassigned to other genera by Garratt (1981a). Hall (1914) described the monograptids *Monograptus aplini* and *M. turriculatus* from Aplin's (1868) section at Keilor and correlated them with zones 22 and 23 of the British Llandovery.

Jones (1927) described *Monograptus chimaera, M. roemeri, M. colonus* and *M. variaus* from Studley Park, and correlated them with Elles & Woods' (1901-1918) zone 33 of the early Ludlow of Britain.

Thomas & Keble (1933) recognised 3 local Silurian Series

3. Yarravian (youngest)

2. Yeringian
1. Keilorian (oldest)

1. The Keilorian (Llandovery) is typically exposed at Keilor. The top of the series was marked by the occurrence of *Monograptus riccartonensis*, which incidentally was misidentified by Chapman (1914, p. 222).
2. The Yeringian (Wenlock) typically exposed at Lilydale and based on age determinations of the shelly fauna by McCoy (1874-1888) and Chapman (1914).
3. Yarravian (=Melbournian) typified by the widespread distribution of zone 33 graptolites in the Melbourne area.

Gill's (1941) sequence was as follows: 1. Keilorian, 2. Melbournian, 3. Jordanian, typically exposed in the Jordan River, and including the beds of the *Panenka-Styliolina* association (=Tanjilian), 4. Yeringian (youngest).

Thomas (1960) subdivided the Silurian into four series. He introduced the name Eildonian, which he correlated with the British Wenlock. This series name was earlier used by Thomas (1947, p. 16) for the supposedly Wenlock Eildon beds. The occurrence of the late Wenlock graptolite *Monograptus testis* from Cottles Bridge was cited as indicative of the Eildonian. Thomas (1960) also recognised that the Tanjilian succeeded the Melbournian, and correlated the Tanjilian series with the Upper Ludlow of Britain.

Gill (1965) subdivided the Yeringian into a lower assemblage typified by the fauna of Ruddock's Quarry, G20 of Gill (1942) and an upper assemblage typified by the fauna at Hull Road, Lilydale (Gill, 1942). Strusz (1972) recognised four faunal associations for the Lower Devonian rocks of Victoria based on brachiopods. He accepted Gill's (1965) subdivision of the Yeringian, expanded the faunal lists and noted the possibility of a Pridolian age for the base of the Yeringian. His four faunal associations were: Lower Yeringian (Pridoli to early Pragian); Upper Yeringian (Pragian) Tabberabberan (late Pragian); Buchanian (late Pragian to Early Middle Devonian).

Talent *et al.* (1975) noted that after 1960 the names for the local Silurian series progressively fell into disrepute and the local Victorian Silurian sequence was directly correlated with the British series. Talent *et al.* (1975) recognised eleven graptolite zones in the Australasian Silurian.

BASIS FOR ZONATION OF THE SILURIAN AND DEVONIAN OF THE MELBOURNE TROUGH

No attempt is made to utilise earlier Silurian and Devonian series nomenclature for the Melbourne Trough. Identification of the Silurian graptolite zones relies on recent compilations of the British zonal scheme (Rickards 1976, Rickards *et al.* 1977), the Polish zonal scheme (Teller 1969) and the Australian scheme (Talent *et al.* 1975). Ranges of various graptolites have been shown to differ in different parts of the world during the Silurian (Churkin & Carter 1970, Rickards 1976, Teller 1969). This suggests that there are inherent problems in intercontinental correlations based on graptolites that may de due to facies changes or diachronism. Nevertheless, the *acuminatus*, *"gregarius"*, *crispus*, *testis*, *nassa* (the *dubius-nassa* interregnum) and *nilssoni* zones of the Silurian and the *uniformis* to *hercynicus* zones of the Devonian appear to be recognised world-wide and may not be time transgressive. All these zones are represented in southeastern Australia except those of the Devonian (Lochkovian) which are either rare or absent.

GRAPTOLITE ASSEMBLAGE ZONES

The graptolite assemblage zones used herein follow those of Talent *et al.* (1975). Treatment of the graptolite zones is confined to new information (i.e. post 1975), pertinent pre-1975 information not mentioned by Talent *et al.* (1975), and those graptolite zones which are important for brachiopod correlation.

The base of the Silurian is yet to be recognised in the Melbourne Trough. The contact between the Ordovician and the Silurian is either faulted, unexposed, or represented by an unfossiliferous interval (Webby 1976, Sherwin 1979, A.H.M. VandenBerg 1981 pers. comm., Richards & Singleton 1981).

Orthograptus cf. *acuminatus* Assemblage Zone

This zone is defined by the presence of rare *Orthograptus* cf. *acuminatus* near Konagaderra northwest of Melbourne, and *Glyptograptus* cf. *persculptus* near Mt Wellington (Harris & Thomas 1954, Talent *et al.* 1975, p. 54). The zone has also been recognised in Tasmania by Baillie *et al.* (1978).

Coronograptus gregarius Assemblage Zone

The *gregarius* zone is present in the Jackson's Creek section at Sydenham, north west of Melbourne (Fig. 2). Thomas & Keble (1933, p. 59) and Harris & Thomas (1949) recorded an assemblage of graptolites from localities 8a and 8b (300 m above the base of the Ordovician-Silurian boundary) in Jackson's Creek as *Monograptus triangulatus fimbriatus, Pristiograptus concinnus, Glyptograptus tamariscus,* and *G. sinuatus.* To this should be added a specimen in their collection identified as *Climacograptus scalaris* s.s. by R. B. Rickards (1977, written communication) from loc. 8b. The underlying 300 m are unfossiliferous. The *gregarius* zone may also be recognised at Heathcote where Thomas (*in* Öpik 1953, p. 10) recorded *P. (M.) hughesi* and *Pristiograptus* cf. *jaculum* from the *Illaenus* Band (Fig. 2).

Monograptus turriculatus Assemblage Zone

This zone may be recognised in the Jackson's Creek Section at Sydenham, where Thomas & Keble (1933, p. 60) recorded *M. sedgwickii* from the base of the Springfield Formation at loc. 7. Their material has been reidentified as *M.* cf. *marri* (R. B. Rickards 1977 pers. comm.). This horizon underlies strata containing an *exiguus* Zone assemblage (locs 5 and 6 of Thomas & Keble, 1933) by some 150 m (Fig. 1).

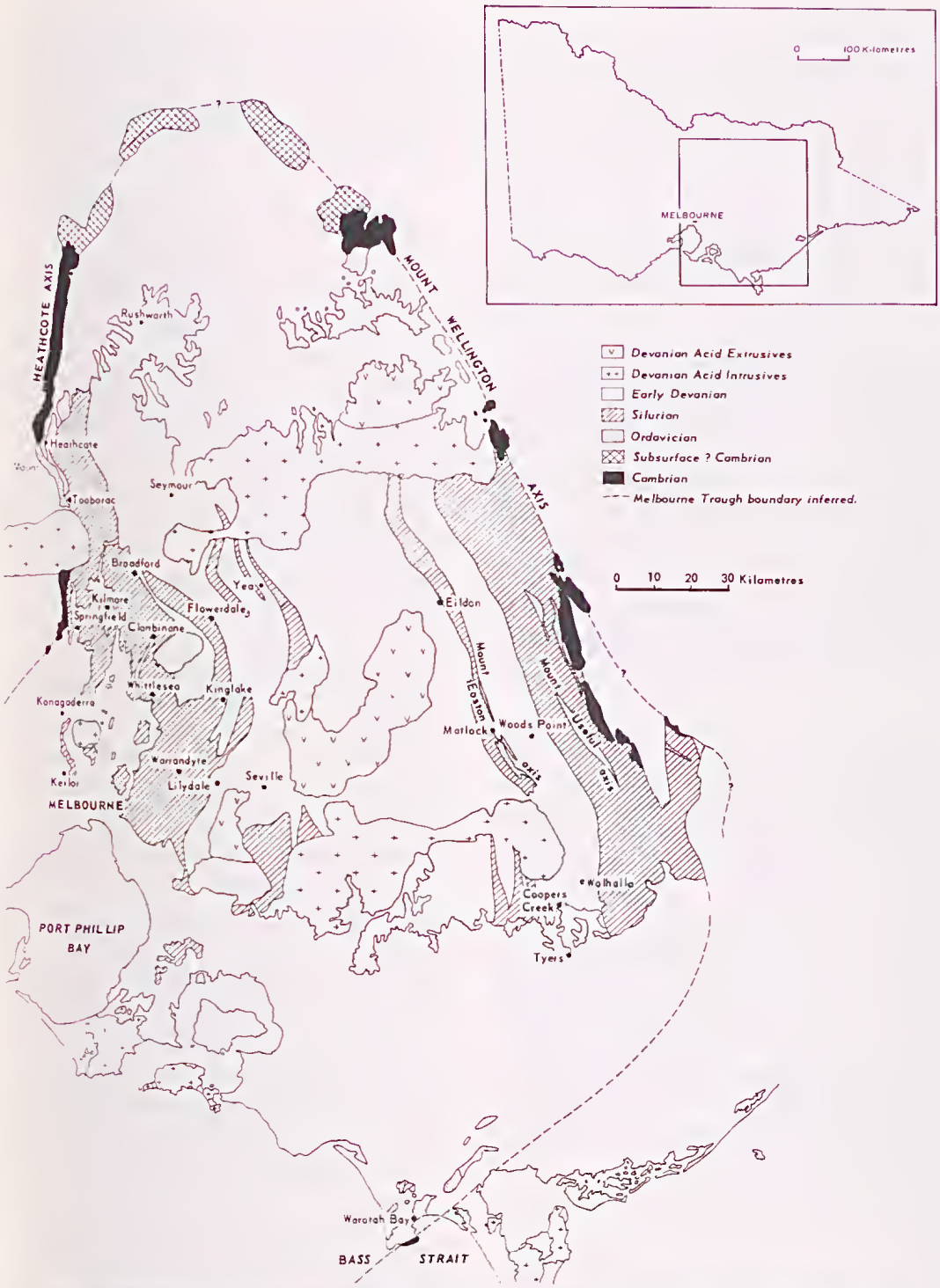

Fig. 1—Locality map of the Melbourne Trough. The Silurian is shown with oblique hatching; the Devonian as blank.

Harris & Thomas (1937, p. 73, 74) found *M. priodon* and *M. runcinatus* at two localities near the base of the Springfield Formation in No. 3 Creek, allotments 20 and 9 respectively, Parish of Springfield (Fig. 2). A *maximus* to *turriculatus* zone age is indicated.

Monograptus exiguus Assemblage Zone

M. exiguus is widespread in the Melbourne Trough and in New South Wales and probably corresponds to the *crispus* and *greistonensis* zones of Great Britain (Rickards 1976) as well as the *M. crispus* Zone of Sher-

rard (1954, p. 90). In Poland *M. exiguus* ranges from the *turriculatus* to *crispus* zone (Teller 1969).

The *exiguus* zone occurs 150 m above the base of the Springfield Formation (VandenBerg & Schleiger 1972) at localities 5 and 6 along Jackson's Creek (Thomas & Keble 1933, Fig. 2), where *M. crispus, M. rickardsi* (earlier identified as *M. halli* by Thomas & Keble 1933) (R. B. Rickards 1977 pers. comm.), *M. marri*, and *Pristiograptus nudus* are found. The zone is also known from isolated localities in the Anderson Creek Formation near Macclesfield, south of Lilydale (fauna includes *M. marri, M. Priodon,* and *M.* cf. *spiralis*, D. E. Thomas and P. R. Kenley 1968, pers. comm.) at Warrandyte (Gill 1952) and at Arthurs Creek (Garratt 1972). The *exiguus* zone is known from several localties in the McAdam Sandstone (VandenBerg 1975b) which crops out within the Mount Easton "Axis" in the eastern portion of the Melbourne Trough. Here, Keble & Harris (1934) and Harris & Thomas (1947) recorded the assemblage *M. exiguus, M. marri* (earlier identified as *M. pandus*), *M. spiralis, M. priodon, Retiolites geinitzianus.*, (earlier identified as *Stomatograptus australis*), and ?*Rastrites*. This collection has been re-examined by R. B. Rickards (1977 written communication). In the Waratah Bay district an inlier of Silurian sandstone and shale has yielded an assemblage of *M. marri* (recorded as *M.* cf. *pandus*) and *Dictyonema* sp. by Douglas & Paton (1972); an assignment to the *exiguus* zone may be indicated.

Testograptus testis Assemblage Zone

For the distribution of this zone in New South Wales see Talent *et al.* (1975). *T. testis* is extremely rare in the Melbourne Trough. Only one specimen has been found at Cottles Bridge approximately 900 m below the top of the Anderson Creek Formation (Garratt 1975), at loc. E9, (Fig. 2).

Gothograptus nassa Assemblage Zone

The "*nassa-dubius* interregnum" (Jaeger 1959) is yet to be documented in Australia (Sherwin 1979, p. 160). Rickards (1976, p. 170) accords this interregnum full zonal rank in Great Britain where it is recognised in North Wales, Ludlow and Wenlock Edge, Shropshire (Holland *et al.* 1969, Bassett *et al.* 1975). Between Melbourne and Warrandyte, *Gothograptus nassa* occurs 10 m (loc. G200a) above an association of *M. flemingi, Pristiograptus pseudodubius* and *Pristiograptus* sp. (loc. G200) (Garratt 1975, Garratt *in* VandenBerg *et al.* 1976), (Figs 2 & 3). Identifications of the lower assemblage are supplied by R. B. Rickards (1977 written communication).

Neodiversograptus nilssoni Assemblage Zone

Sherwin (1979, p. 161) stated that 'the British zones of the early Ludlow cannot be recognised with any exactitude' (for Australia) 'but this is possibly the result of existing uncertainties in England'. Rickards (1976) earlier drew attention to these "uncertainties" and suggested that the *nilssoni* zone s.l., may in fact be differentiated into a lower *nilssoni* zone and an upper *progenitor* zone, as in Poland (Teller 1969).

The *nilssoni* zone was first recognised in Australia by Jones (1927) who described *M. chimaera, M. roemeri, M. varians* and *M. colonus*, from Studley Park, Melbourne. It is also known from Heathcote (Harris & Thomas 1937), Queenstown and Yellingbo (D. E. Thomas & P. R. Kenley 1968 pers. comm.). At Heathcote, the *nilssoni* zone occurs in the upper part of Unit 2 of the Dargile Formation (Thomas 1941a) and underlies a *scanicus* zone assemblage by 400 to 600 m (Fig. 3). Localities H33 and H41, Parish of Heathcote have yielded *Neodiversograptus* cf. *nilssoni* and *Saetograptus colonus* (Fig. 2) whilst locality H35, Parish of Heathcote, has yielded *Monograptus uncinatus* and *Pristiograptus* cf. *dubius*. Within Melbourne, the *nilssoni* zone ranges from close to the top of the Anderson Creek formation up into the Dargile Formation. At Eltham (loc. E1) and Wonga Park (loc. E2) northwest of Lilydale, *S. colonus* occurs in the upper beds of the Anderson Creek Formation (Garratt 1975) (Figs 2 & 3). At Craigieburn (loc. M1), north of Melbourne an equivalent horizon has yielded *Pristiograptus jaegeri, M. ludensis,* and *S. varians* (Rickards *in* VandenBerg *et al.* 1976, p. 48). At Studley Park (loc. M2) the assemblage described by Jones (1927) has been reidentified by Rickards (1977, written communication) as including abundant *S. incipiens* and *S. varians,* occasional *S. colonus,* and very rare *S. roemeri,* to which should be added *Lobograptus crinitus* (Harris & Thomas 1937, p. 12, Fig. 3). Localities M3, 4 and 5 within the City of Melbourne contain *S. varians, S. colonus, N.* cf. *nilssoni,* and *Pristiograptus dubius* (Thomas & Keble 1933, p. 76). Recent excavations during the construction of the Melbourne Underground Rail Loop have shown that structurally and stratigraphically these localities lie beneath the starfish beds of Withers & Keble (1934a, b) (e.g. M6) by approximately 50 m (J. Neilson 1978, pers. comm.). Elsewhere in the western portion of the Melbourne Trough, the starfish beds contain *S. chimaera,* a species which is indicative of the overlying *scanicus* Zone, suggesting that at least two starfish horizons occur in the early Ludlow of the Melbourne Trough.

D. E. Thomas & P. R. Kenley (1968, pers. comm.) found *N. nilssoni* and *Bohemograptus bohemicus* at Cottles Bridge (loc. M7) and this locality was shown by Garratt (1972) to be above the base of the Dargile Formation. This assemblage together with *S.* cf. *colonus* occurs at Yellingbo (loc. M8) east of Macclesfield (Figs 2 & 3). *S. colonus* is known from localities D140 and D143 at Whittlesea (Williams 1964, p. 283, Fig. 3a), and *Bohemograptus bohemicus* occurs at locality E3, 1.5 km east of the junction between Watson Creek Road and Panton Hill Road, Christmas Hills. These localities occur between 50 and 200 m above the base of the Dargile Formation.

Saetograptus scanicus Assemblage Zone

At Heathcote, Harris & Thomas (1937, p. 71, pl. 1, figs 9-12) illustrated and described *S. chimaera, S. colonus* var. *compactus* from locality 40, Parish of Redcastle and loc. 37, Parish of Heathcote; the latter locality

also yielded *Bohemograptus bohemicus*, and *Monograptus uncinatus*. *S. chimaera* has been recorded from localities 35A and 32, Parish of Heathcote and locality 8D, Parish of Dargile (Harris & Thomas 1937, p. 72). All occur close to the top of Unit 3 of the Dargile Formation as mapped by Thomas (1941 a, b), and overlie localities containing *nilssoni* zone graptolites by 400-600 m (Fig. 3).

Williams (1964, p. 283, fig. 3g) described *Monograptus varians* var. *pumilis* from locality F31 (= Bb23 east of Kilmore) but it was later reidentified as *S. chimaera* by Jaeger (1967, p. 284). It occurs in sandstone containing starfish which are stratigraphically below the *Aegiria-Encrinurus* beds (Garratt 1977).

Graptolite Occurrences between the *scanicus* and *thomasi* Assemblage Zones

In the western portion of the Melbourne Trough sporadic isolated occurrences of graptolites are known over a stratigraphic range from the upper beds of the Dargile Formation and the overlying Humevale Formation (Williams 1964, Garratt 1979). All the species so far recovered range through the Ludlow. These localities give an upper and lower age limit to the *Aegiria thomasi* and *Notoparmella plentiensis* assemblage zones respectively.

Monoclimacis cf. *haupti* and *Bohemograptus bohemicus* are known from Arthurs Creek (locality T8) (D. E. Thomas & P. R. Kenley 1968 pers. comm.) and Upper Plenty (locality F10 Williams 1964, p. 283, Fig. 3F), and are high in the Dargile Formation (Garratt 1972, 1977). They correlate with the *Aegiria-Encrinurus* mudstones (Unit 4 of the Dargile Formation); a late Ludlow age is suggested.

At Yea, two localities within the upper 40 m of the Yea Formation contain *Bohemograptus bohemicus* and *P.* cf. *dubius*, and *Monograptus* cf. *uncinatus uncinatus* respectively (R. B. Rickards 1980 pers. comm., Garratt 1981a, 1981b). These localities occur in the Lower Plant Assemblage (Garratt 1979, 1981b) which contains elements of the *Baragwanathia* flora (Douglas 1976 unpubl., Garratt 1979) and strongly implies a Ludlow age for the earliest *Baragwanathia* flora, perhaps as old as *scanicus* Zone. They have been correlated with the upper beds of Unit 4 of the Dargile Formation. The overlying sandstones of the Rice's Hill Sandstone Member at Yea, and the Clonbinane Sandstone Member at Broadford, Flowerdale and Whittlesea are considered coeval, although lithologically distinct (Fig. 5).

Three localities containing probable Ludlow graptolite assemblages are known from the Humevale Formation. Williams (1964, p. 283, fig. 3) illustrated a form as *Monograptus* cf. *dubius thuringicus* from loc. X50 at Reedy Creek, 100 m above the Clonbinane Sandstone Member. This specimen has been reidentified as *P.* cf. *haupti* by Jaeger (1977 written communication). Further east at Tunnell Hill between Flowerdale and Yea, Williams (1964) illustrated a form as *M.* cf. *uncinatus* from loc. E56, approximately 900 m above the Clonbinane Sandstone Member (Figs 2, 5). At loc. E10, Strath Creek, and at approximately the same stratigraphic position as loc. E56, *B. bohemicus*, *P. dubius* and *Linograptus* sp. have been recovered (Garratt, 1979). These graptolite localities, although widely distributed suggest an upper age limit for the Clonbinane Sandstone Member, of late Ludlow. This conflicts with Schleiger's identification (*in* VandenBerg *et al.* 1976, p. 51) of the Pridoli form *M. aequabilis aequabilis* from just above the Clonbinane Sandstone Member at Coulson's Crossing, Clonbinane. Clarification of this conflict must await description of these graptolites from Coulson's Crossing.

Monograptus thomasi Assemblage Zone

The *M. thomasi* Assemblage Zone was first established in Victoria by Jaegar (1966, 1967). It is widely distributed, both vertically and laterally in the Wilson Creek Shale of the Melbourne Trough (Talent & Banks 1967, VandenBerg 1975b, VandenBerg *et al.* 1976). It is not known elsewhere in southeastern Australia, although Sherwin (1979, p. 161, 2) recorded a form as *M.* aff. *thomasi* in association with *M. transgrediens* from Cheeseman's Creek, New South Wales.

M. thomasi Zone has been found in Malaya (Jones 1973), Guangxi Province of China (Mu & Ni 1975, Wang 1975), Nevada, U.S.A. (Berry & Murphy 1972, Johnson 1977b), and Western Canada (Jackson *et al.* 1978, Lenz 1979, Jaeger 1979).

There is uncertainty as to whether the *thomasi* zone is 'early' or 'late' Pragian. Consideration of this problem hinges on the stratigraphic relationship between the *thomasi* zone and *sulcatus sulcatus* zone, as well as their relationship with other Pragian graptolites. Evaluation of the stratigraphic position of the *thomasi* zone in the Early Devonian of the Melbourne Trough is hampered by the absence of Lochkov graptolite zones and by the facies control of the *thomasi* zone within the Wilson Creek Shale, both the lower and upper boundaries of the *thomasi* zone are coincident with the lower and upper boundaries, respectively, of the Wilson Creek Shale. At Eildon, Matlock and Walhalla, the upper few metres of the Wilson Creek Shale contain *M. aequabilis notoaequabilis* as well as *M. thomasi*. *M. aequabilis notoaequabilis* is found in the overlying siltstones of the Norton Gully Sandstone (VandenBerg 1975b). Further west at Killingworth, near Yea, *M. thomasi* is found in a tongue of Wilson Creek Shale above the Flowerdale Sandstone Member (loc. 10 of Harris & Thomas 1942) (Couper 1965, Garratt 1979). At Seymour, *M. thomasi* occurs in two tongues of Wilson Creek Shale—the lower tongue above the Flowerdale Sandstone Member (loc. F2) and the upper tongue immediately overlying the Broadford Conglomerate Member (locs. F1, F3 and F5 of Schleiger 1964). *M. aequabilis notoaequabilis* is found in association with *M. thomasi* at loc. 1 near Seymour, and is also known from a higher tongue of the Wilson Creek Shale at loc. F4 near Sanitary Gully, east of Seymour (Schleiger 1964). Thus the graptolite succession replicates that of Matlock, but over a thicker sequence of strata (Garratt 1979, Fig. 4). At Yea,

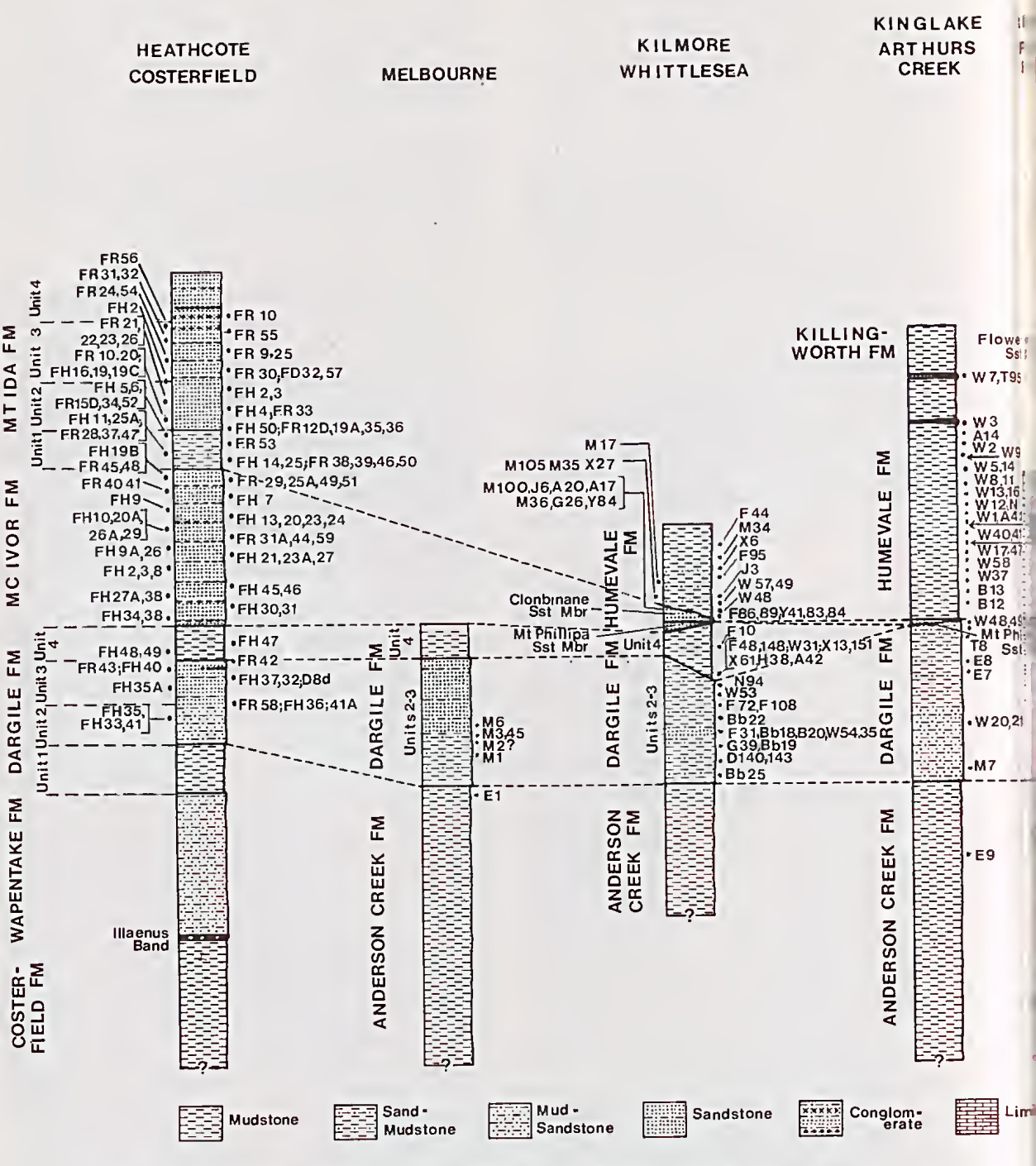

Fig. 3—Composite lithostratigraphic correlation of Silurian-Devonian of south central Victoria. Note that the fossil locality captions are published as far as Heathcote (Talent 1965a) Kilmore and Kinglake (Williams 1964), and Lilydale and Seville (Gill 1942, VandenBerg 1971). Other localities not included in the above publications are listed by Garratt (1981, unpubl.).

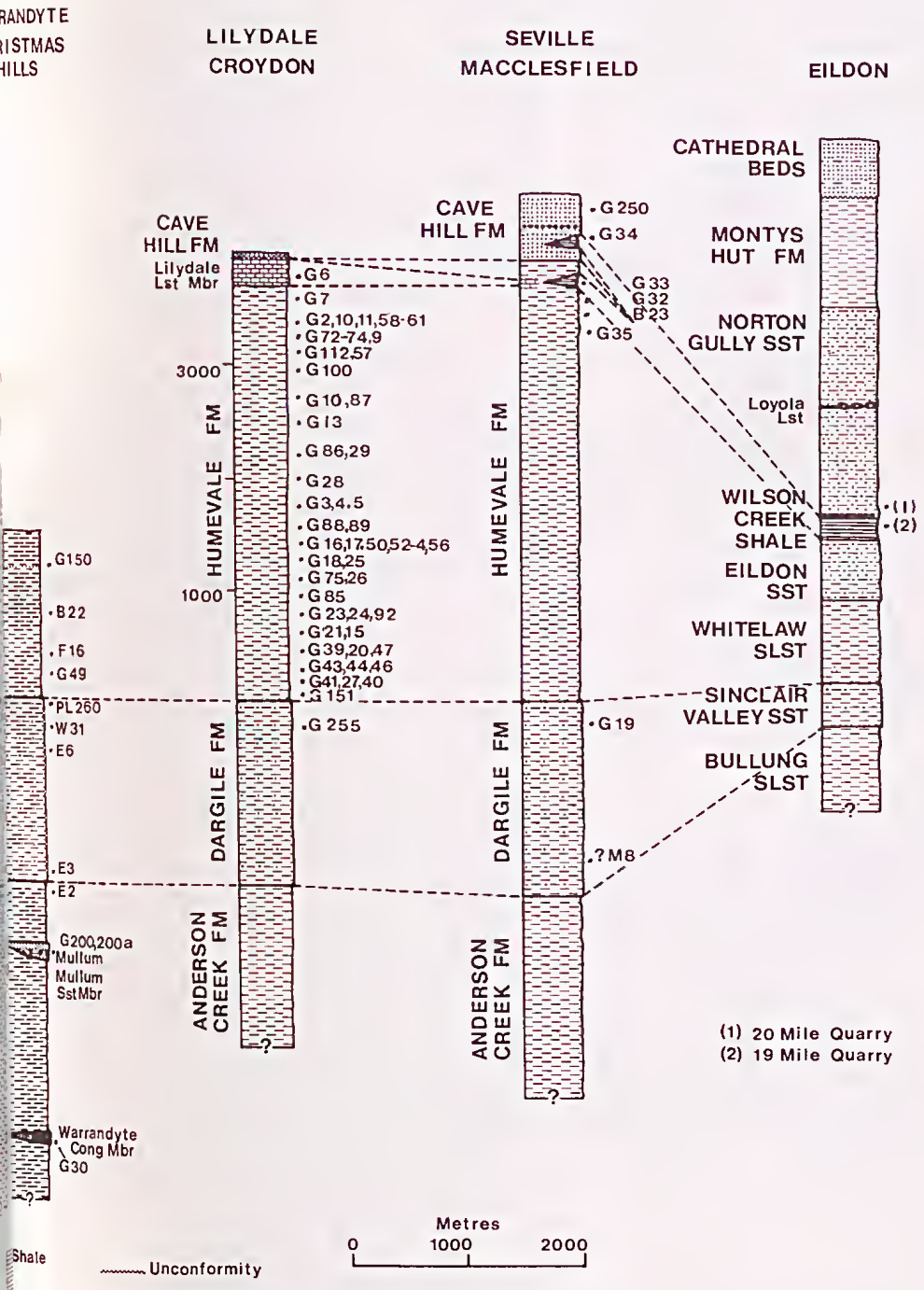

Fig. 3—(*continued*)

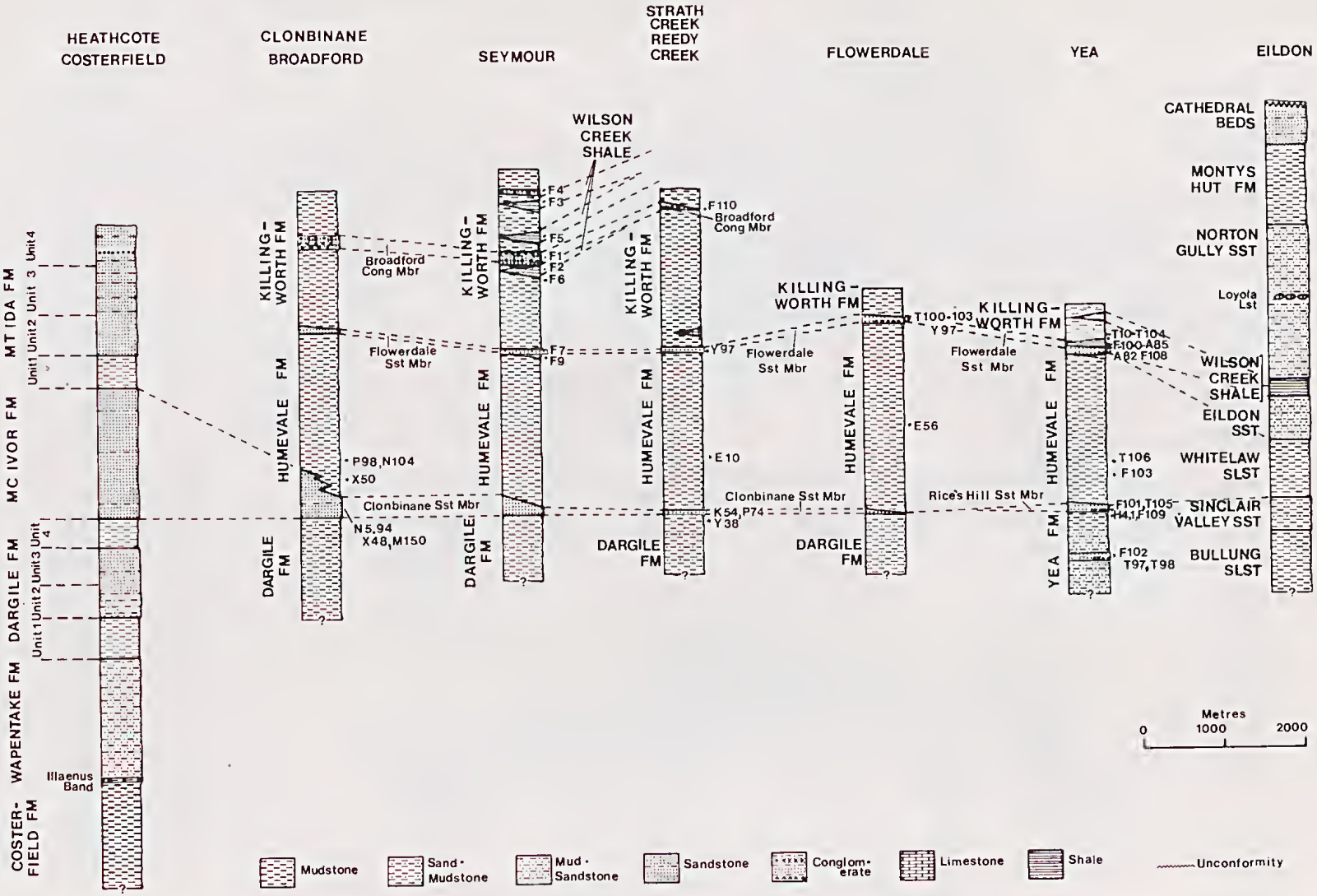

Fig. 4—Composite lithostratigraphic correlation of Silurian-Devonian of north central Victoria. Note that the fossil locality captions are published as for Clonbinane, Strath Creek, Flowerdale and Yea (Williams 1964) and Seymour (Schleiger 1964). Other localities not included in the above publications are listed by Garratt (1981, unpubl.).

Seymour, Eildon and Matlock these graptolite assemblages occur with elements of the *Baragwanathia* flora and the Tanjilian shelly assemblage—*Nowakia acuaria*, *"Panenka"* and *"Orthoceras"*.

The presence of *M. aequabilis notoaequabilis* in the Wilson Creek Shale provides a link with the Bohemian sequence of central Europe where it is found in association with *M. yukonensis* in the Dvorce-Prokop Limestone which is considered by Jaeger (1970, 1979), and Strusz (1972, p. 445) to be 'late' Pragian in age, but nowhere in Australia is it found in association with *M. aequabilis notoaequabilis*.

In the northern Canadian Corillera, Lenz, (1979) has described a Pragian graptolite assemblage from the Road River Formation exposed in the Peel River. He recorded *M. fanicus* 215 m below beds containing *M.* cf. *thomasi* and 45 m above beds containing *M. aequabilis notoaequabilis*. He correlated this sequence with the *fanicus* zone at Tien Shan which Koren (1974, 1975) considered as Pragian. She noted the long vertical range of *M. aequabilis notoaequabilis*. Unfortunately *M. thomasi* has not been recorded from the Tien Shan. Jaeger (1979) placed the *thomasi* zone in the 'late' Pragian overlying the *fanicus* zone. This would be supported by Lenz's (1979) work in northern Canada, if his provisional identification of *M. thomasi* can be confirmed. The evidence provided by the conodont and brachiopod zonations of Nevada however, suggests that the *thomasi* zone is an 'early' rather than 'late' Pragian zone (Klapper 1977, Johnson 1977a, b). It must be emphasised that as yet no Pragian conodont zonation for the Bohemian succession has been established, although H. Jaeger (1980 pers. comm.), has noted that Schlonlaub has discovered *Icriodus pedavis pesavis* associated with *hercynicus* zone graptolites in the upper beds of the Lockhov Formation. For this reason the *pedavis pesavis* zone is here considered to be 'late' Lochkov (Fig. 2). Two critical sections, one in Nevada, and the other in Victoria indicate that the *thomasi* zone is partly coeval with the *Eognathodus sulcatus sulcatus* zone, here considered to be 'early' Pragian. *Monograptus thomasi* is found in the type section of the Rabbit Hill Limestone, Nevada (Berry & Murphy 1972, Matti *et al.* 1975), a short distance below an assemblage of brachiopods and conodonts (Johnson 1973, 1974) which Johnson (1977b) assigned to the *Spinoplasia* zone (Johnson 1965, 1970). This zone succeeds the 'late' Lochkov *Quadrithyris* zone and belongs to the Pragian (Johnson 1977a, 1977b). Klapper (1977) assigned the conodonts from this part of the section to the *sulcatus sulcatus* zone. At both Jacobs Creek, near Tyers, and along the Thomson River in the eastern part of the Melbourne Trough, blue-black shales on strike with the Wilson Creek Shale to the north are interbedded with thin micritic limestones. At Jacob's Creek the shales contain *Monograptus thomasi*. The limestones contain the conodonts *Eognathodus sulcatus sulcatus* and *E. trilinearis* (Cary & Bolger in prep). Thus the *thomasi* zone correlates with the *sulcatus sulcatus* zone and evidence given here suggests that the Victorian sections also correlate with the Rabbit Hill section of Nevada, U.S.A.

CONODONT ASSEMBLAGE ZONES

These are briefly discussed because their occurrence within the restricted limestones of the Early Devonian helps to place an upper age limit to 1, the upper beds of the Humevale Formation at Lilydale and Seville, 2, the Boola Beds at Tyers, and 3, the widely distributed Wilson Creek shale.

Eognathodus sulcatus sulcatus Assemblage Zone

The *sulcatus sulcatus* assemblage zone (Fahreus 1971, Klapper 1977) as used in Australia by Klapper & Zeigler (1979) has been recognised in the Waratah, Coopers Creek and Lilydale Limestones of the Melbourne Trough (each represented by a single locality), principally through the works of Philip (1965), Philip & Pedder (1967), Strusz (1972), Argent (1971 unpubl.), and Cooper (1973b), in NSW (Druce 1970, Pickett 1980), in the Yukon territory (Fahreus 1971, Klapper 1977), and in Germany (Al-Rawi 1977). The type locality of *E. sulcatus sulcatus* is the old Tyers Limestone Quarry (loc. 11 of Philip 1962) on the east bank of the Lower Tyers River, Gippsland, Victoria (Philip 1965). All the Victorian occurrences of *E. sulcatus sulcatus* from the Lilydale, Waratah and Coopers Creek Limestones are considered coeval and 'early' Pragian in age.

Conodont occurrences above the *sulcatus sulcatus* Assemblage Zone

Eognathodus trilinearis and *Polygnathus* sp. are known from the Loyola Limestone of Loyola (Cooper 1973b). The Loyola Limestone is stratigraphically 1000 m above the Coopers Creek Limestone and Wilson Creek Shale (Figs 2, 3). This level may be as high as the *dehiscens* zone. Such an assignment would depend upon the identification of *Polygnathus* sp. However the inclusion of *E. trilinearis* in the Loyola Limestone, known to occur with *E. sulcatus sulcatus* at Jacob's Creek would suggest that the Loyola Limestone is no younger than *sulcatus* n. sub. sp. zone. The exact dating of the Loyola Limestone is further complicated because stratigraphic relationships between the limestone and the surrounding sediments is unclear. The Loyola Limestone is included within a thick matrix-supported conglomerate unit with both rounded clasts and angular contorted mudstone clasts and VandenBerg (1975b) has suggested that the limestone pods may be megaclasts.

Nowakia acuaria Assemblage Zone

The *Nowakia acuaria* assemblage zone (Boucek 1964) was recognised in Australia by Lütke (1979), and ranged from 'late' Lochkov to 'early' Pragian. *N. acuaria* is widely distributed in the Melbourne Trough (Talent 1965b, Talent & Banks 1967, VandenBerg 1975b, VandenBerg *et al.* 1976, Cooper 1973a). It occurs as a distinct 'marker' horizon in the Norton Gully Sandstone, throughout the eastern half of the Melbourne Trough. In the western portion of the Melbourne

Trough *Nowakia acuaria* is found in association with *M. thomasi* immediately above the Flowerdale Sandstone Member of the Killingworth Formation at Yea (loc. F100), Seymour and Strath Creek (Garratt 1979). At Lilydale, it occurs in the upper beds of the Humevale Formation (locs. G1, G2, G9 and G87) and at Seville in the Cave Hill (Figs 2, 3). The upper beds of the Humevale Formation are considered 'late' Lochkov in age because they conformably underlie the *sulcatus sulcatus* bearing Lilydale sequence with the Bohemian sequence while *N. acuaria* makes its first appearance within the *Monograptus hercynicus* zone of the 'late' Lochkov (Lütke 1979). Other occurrences of dacryoconarid species are known at Lilydale at various horizons within the Humevale Formation (VandenBerg 1975b, VandenBerg *et al.* 1976), but they are yet to be studied in detail.

BRACHIOPOD ASSEMBLAGE ZONES

Although brachiopods are found sporadically in the Llandovery and Wenlock of the Melbourne Trough (see Fig. 2) it is not until the Ludlow that the faunas are sufficiently abundant to allow for the delineation of Assemblage Zones. During the Late Silurian the benthos is largely confined to the western margin of the trough from Heathcote, south, through Kilmore to Melbourne. However, by the Early Devonian, favourable environments extended into the Kinglake and Lilydale areas and locally near the eastern margin. Shelly faunas of the Llandovery and Wenlock strata have been described from Heathcote (Öpik 1953), Warrandyte (Gill 1952), and Springfield as reported by Talent *et al.* (1975).

The brachiopod assemblage zones of southeastern Australia (Fig. 2) are dated by either:

(1) graptolites, conodonts and/or dacryoconarids occurring at the same locality or in the same stratigraphic section as the brachiopod assemblages.
(2) correlation of the brachiopod assemblage zones with sections elsewhere in the Lachlan Fold Belt.
(3) correlation of brachiopod assemblage zones with sections outside Australia (e.g., New Zealand, North America, Europe and Asia).
(4) stratigraphic mapping of sediments in the Melbourne Trough.

The five brachiopod assemblage zones are regarded as being equivalent to the Yeringian of Gill (1965). Strusz's (1972) distinction of three faunas within this interval, (i.e., the Lower Yeringian Fauna, Upper Yeringian Fauna, and the Tabberabbera Fauna) is not accepted. 'Yeringian' faunal elements previously considered to be indicative of the uppermost Silurian and Lower Devonian (Talent 1965a, b, Strusz 1972), extend down into lower Ludlow (= Melbournian of Gregory 1903). For example, *Pleurodictyum megastomum, Lissatrypa lenticulata, Notoconchidium thomasi, Maoristrophia banksi, Plectodonta bipartita* and *Leptostrophia plateia* are found in strata in varying associations with lower to upper Ludlow graptolite zones at Kilmore, Whittlesea and Melbourne.

In the correlation between different areas of the Melbourne Trough the influence of sediment type as a control of faunas cannot be under estimated. For example, there is a contrast between the faunas of the shallow neritic sandstones of the Heathcote and Clonbinane districts with those of the shallow neritic mudstones of the Lilydale district. The preservation of the assemblages in the McIvor and Mt Ida Formations may be poor compared with the mudstones of the Lilydale sequence. The differences are regarded as due to ecological control.

HEATHCOTE (sandy)	LILYDALE (muddy)
Salopina sp. nov. A	*Salopina* sp. nov. B
Leptostrophia plateia	*Leptostrophia alata*
Maoristrophia banksi	*Maoristrophia keblei*
Mesodouvillina limbimura	*Mesodouvillina lilydalensis*
Notoleptaena otophera	*Notoleptaena linguifera*
Strophonella gippslandica	*Hipparionyx major*
Notoconchidium thomasi	*Cymostrophia euglyphoides*
Molongia sp. nov.	*Gypidula victoriae*

However, some forms with wider ecological tolerance (for example, *Aegiria thomasi*, the Notanopliidae, Cyrtidina and the Spiriferidina) are found in sandy, muddy and limey facies between Heathcote, Kinglake, Lilydale and Tyers, and the ranges of the species in these groups are considered to be biostratigraphically important.

Aegiria thomasi Assemblage Zone

The base of the *A. thomasi* zone is defined by the appearance of *A. thomasi* which has a wide geographic distribution and ranges throughout the zone. *Amphistrophia lyelli* and *Hedeina* sp. nov. are diagnostic of the *A. thomasi* zone, but have only been found at Kilmore (Fig. 6). *Lissatrypa lenticulata, Leptaena* sp., *Leptostrophia plateia, Isorthis* sp. nov. A, *Salopina* sp. nov. A, *'Protochonetes' melbournensis, Nucloespira* sp. nov., *Molongia* sp. nov., *Camarotoechia* sp., and *Stegerhynchus* sp. appear at different intervals within the *A. thomasi* zone and with the exception of *'P' melbournensis*, range into the succeeding zones (Figs 5, 6, 7).

The type locality for the zone is at Heathcote (Thomas 1937), where it includes Units 2, 3 and 4 of the Dargile Formation and it is also recognised between Kilmore, Whittlesea and Melbourne. In the upper part of the zone *A. thomasi* increases in abundance and together with the trilobite *Encrinurus simpliciculus* dominates the lower beds of Unit 4 of the Dargile Formation between Heathcote and Whittlesea.

The base of the *A. thomasi* zone lies within the *nilssoni* zone at Heathcote, Melbourne and Whittlesea (Fig. 2). *Saetograptus varians, S. chimaera, Lobograptus colonus* and *Bohemograptus bohemicus* are found in varying combinations at Heathcote, Whittlesea and Melbourne either at the same locality (e.g., F31, Kilmore East), or close by and along strike (compare Figs 2, 3 with Figs 5, 6 and 7), to localities yielding *A. thomasi*. The upper boundary of the *A. thomasi* zone cannot be satisfactorily linked with a graptolite zone. At

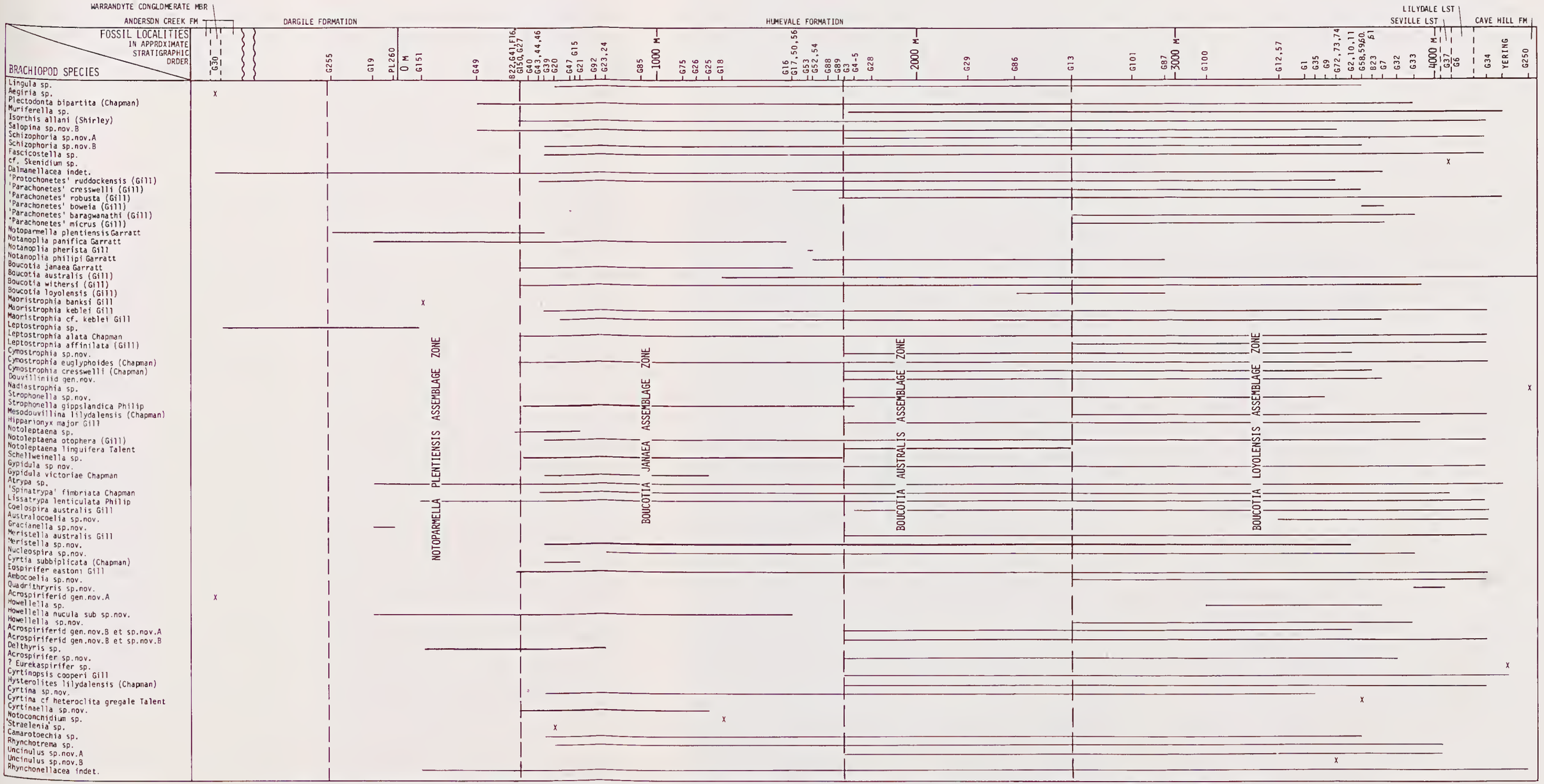

Fig. 5—Range chart of brachiopod species of Lilydale-Seville district, Victoria. The continuous horizontal lines represent the known vertical range of the species in the area. It does not mean that at each locality all species will be represented. The data on the distribution of brachiopods and the assemblage at each locality is available from the author. Collections are stored in the National Museum of Victoria and the lists are prepared from collections made by A. Selwyn, G. Sweet, A. Cresswell, J. Jutson, G. Pritchard, E. Gill, T. Darragh and the author.

locality F10, Whittlesea, *B. bohemicus* occurs in the upper 50 m of the *A. thomasi* zone, indicating a Ludlow age for the top of the zone. At Heathcote, the top of the zone is marked by a facies change from mud to sand and for the next 1700 m of strata none of the enclosing fauna is diagnostic of either the Late Silurian or Early Devonian. The *A. thomasi* Zone may occur in the Bullung Siltstone of the Warburton-Matlock district, where VandenBerg (1975b, p. 8) recorded a suite of shelly fossils including *Aegiria* sp., *Lissatrypa* sp., *Plectodonta* sp., *Macropleura* sp., *Pleurodictyum megastomum* and *Encrinurus* sp.

Notoparmella plentiensis Assemblage Zone

The type locality of the *plentiensis* zone is at Upper Plenty, north of Whittlesea, in the lower beds of the Humevale Formation.

The base of the zone is defined by the sudden appearance of many new forms including *Notoparmella plentiensis, Plectodonta bipartita, Salopina* sp. nov. B, *'chonetes'* sp. nov. B and *Maoristrophia banksi* in the lowest beds of the Humevale Formation. Rare specimens of *N. plentiensis* are found in Unit 4 of the Dargile Formation but it increases in abundance in the lower 600 m of the Humevale Formation at Upper Plenty where it dominates the fauna together with occasional specimens of *Lissatrypa lenticulata* (long ranging) *Gracianella* sp. nov., *Isorthis* sp. nov., *Salopina* sp. nov. B, and *'Eatonia'*-like rhynchonellids.

Between Christmas Hills and Lilydale, the *plentiensis* Zone is recognised by an impoverished fauna of *Notoparmella plentiensis, Plectodonta bipartita, Gracianella* sp. nov., *Howellella nucula* subsp. nov., rare *Maoristrophia banksi, Notanoplia panifica* and *Salopina* sp. nov. B. The Zone extends from the upper beds of the Dargile Formation to the lower 400 m of the Humevale Formation (Fig. 5). This assemblage contrasts with the richly diverse assemblage at Kinglake, suggesting an increasing water depth east from Kinglake at this time (Williams 1964, Garratt in press).

At Heathcote, *Notoparmella plentiensis, Gracianella* sp. nov. and *Notanoplia panifica* are absent. But the *plentiensis* zone is recognised by the appearance of *Maoristrophia banksi, Notoconchidium thomasi* and *Salopina* sp. nov. B., all of which appear in the *plentiensis* zone at Kinglake. Locally at Heathcote, *Sowerbyella plebeia* appears in this faunal interval. In the Flowerdale-Yea district the *plentiensis* zone is represented by the rare and probably allochthonous occurrence of *Notoparmella plentiensis, Maoristrophia banksi, Howellella* cf. *nucula* subsp. nov. and rhynchonellids at localities H1 and H4. *H.* cf. *nucula* subsp. nov. also occurs at F101 and F102 at Yea. These localities are scattered through 100 km, of the Yea Formation through to the overlying Rice's Hill Sandstone Member (Fig. 4).

The Ludlow age for the *plentiensis* zone is based on six widely scattered graptolite localities occurring either below or within the *plentiensis* zone:

1, loc. F10, Upper Plenty: *Bohemograptus bohemicus* occurs 100 m below the base of the *plentiensis* zone in Unit 4, Dargile Formation (Williams 1964).

2, loc. X50, Reedy Creek: *Pristiograptus* cf. *haupti* occurs 100 m above the base of the *plentiensis* zone in Humevale Formation.

3, loc. E10, between Strath Creek and Reedy Creek: *Bohemograptus bohemicus, Pristiograptus* sp. and *Linograptus* sp. are found approximately 900 m above the base of the *plentiensis* zone (Garratt 1979) in Humevale Formation.

4, loc. E56, Flowerdale, *Monograptus* cf. *uncinatus* occurs approximately 900 m above the base of the *plentiensis* zone in Humevale Formation (Williams 1964).

5, loc. H1, Yea, *M.* cf. *uncinatus uncinatus* occurs immediately below the Rice's Hill Sandstone Member (and approximately 100 m above the base of the *plentiensis* zone) (R. B. Rickards 1980 written communication).

6, loc. H4, Yea: *B. bohemicus* occurs at the same stratigraphic level as (5), (G. Packham 1977 written communication, R. B. Rickards 1980 written communication).

Thus the basal half of the *plentiensis* zone at Clonbinane, Yea and Kinglake can be no older than early Ludlow. The upper boundary of the zone cannot be related to either graptolite or conodont zones owing to the complete absence of established Pridolian to Lochkovian graptolites and conodonts in the Melbourne Trough.

Boucotia janaea Assemblage Zone

The base of *janaea* zone is defined by the abrupt appearance of abundant *B. janaea*, and nine other species, many of which are important in delineating the Silurian-Devonian boundary at Lilydale (Fig. 5). Fifteen other brachiopod species appear about 200 m higher in the section. This zone comprises Strusz' (1972) "Lower Yeringian Fauna". Seven of the species occurring in the *janaea* zone at Lilydale appear at the same stratigraphic level in the Kinglake district. There are: *B. janaea, Salopina* sp. nov. A. *"Protochonetes" ruddockensis, Leptostrophia alata, Cymostrophia euglyphioides, Notoleptaena otophera.* All but *Salopina* sp. nov. A. are important in delineating the Silurian-Devonian boundary in the Kinglake district. At Heathcote the base of the *janaea* zone is recognised by the appearance of *B. janaea* (occasional), *'Protochonetes' ruddockensis, Plectodonta bipartita, Mesodouvillina limbimura, Notoleptaena linguifera, Meristella* sp. nov. and *Cyrtina* sp. nov. Of these, the latter is important in the delineation of the Silurian-Devonian boundary at Heathcote. This boundary is about 100 m above the base of Unit 1 of the Mount Ida Formation (Fig. 7).

Boucotia australis Assemblage Zone

The *australis* zone is found at many localities in Victoria, New South Wales and Tasmania. In Victoria, the *australis* zone is well developed at Lilydale, Kinglake, Heathcote and Tyers, near the eastern margin of the Melbourne Trough. The base of the *australis* zone is recognised by the appearance of *Boucotia australis* and fifteen other brachiopod species at about 1500 m above

the base of the Humevale Formation. Of these *Schizophoria* sp. nov. A., *'Protochonetes' cresswelli, 'P' robusta, Cymostrophia cresswelli, Strophonella* sp. nov., *Hipparionyx major, Gypidula* sp. nov., *Coelospira australis, Meristella australis* and *Hysterolites lilydalensis* are locally abundant. At Kinglake the base of the *australis* zone is about 1600 m above the base of the Humevale Formation, and locally abundant forms such as *Boucotia australis, Notanoplia philipi, N. plerista* indicate a correlation of this level with that at Lilydale. Very rare occurrence of *Cyrtinopsis cooperi, Hysterolites lilydalensis, Muriferella* sp., *Boucotia withersi, Strophonella gippslandica, Australocoelia* sp. nov. and *Eospirifer eastoni* support this correlation.

The base of the *australis* zone at Heathcote is defined by the appearance of *Boucotia australis, Cyrtinopsis cooperi, Hysterolites lilydalensis, Strophonella gippslandica* and *Australocoelia* sp. nov. in Unit 3 of the Mount Ida Formation in the Parish of Redcastle. The *australis* zone is clearly recognisable in the upper sandstones and muddy sandstones of the Boola Formation at Tyers (Philip 1962). Where the assemblage includes *Boucotia australis, Notanoplia philipi, Schizophoria* sp. aff. *S.* sp. nov. A, *Maoristrophia keblei, Strophonella gippslandica, Notoleptaena otophera, Leptostrophia affinilata, Cymostrophia euglyphoides, 'Protochonetes' cresswelli, Spirigerina supramarginalis, Howellella scabra,* and rare *Hysterolites lilydalensis.* The latter species has been found by me in muddy sandstone immediately below the Coopers Creek Limestone at Tyers. *L. affinilata* is not known elsewhere in the Melbourne Trough from the *australis* zone.

Boucotia loyolensis Assemblage Zone

The base of the *loyolensis* zone at Lilydale is defined by the appearance of six new species (Fig. 5) including abundant *Leptostrophia affinilata, 'Parachonetes' baragwanathi, Mesodouvillina lilydalensis* and *Ambocoelia* sp. nov. *B. loyolensis* first appears as a rare species in the upper part of the *australis* zone. At a higher level in the *loyolensis* zone a very large *Schizophoria* species appears, together with *Nadiastrophia* sp., *Australocoelia* sp. nov., *Acrospirifer* sp. nov. A., *Eurekaspirifer* sp., *Cyrtina* cf. *heteroclita gregale* and *Uncinulus* sp. nov. B. These species are important in correlation with Tabberabbera, North America and China. The base of the *loyolensis* zone lies approximately 2 500 m above the base of the Humevale Formation and extends up into the overlying sandstones of the Cave Hill Formation at Seville, east of Lilydale (Fig. 5).

At Yea and Flowerdale the *loyolensis* zone is represented by an allochthonous assemblage found in the graded sandstones, matrix-supported and clast-supported conglomerates of the Flowerdale Sandstone Member and the Broadford Conglomerate Member at Strath Creek. These transported assemblages include those which are typical of the *australis* zone, in particular the brachiopod species occurring in the Flowerdale Sandstone Member (localities T100-T104, Y97) at Flowerdale, for example, *Boucotia australis, Plectodonta bipartita, Isorthis festiva, Tyersella typica, Leptostrophia alata, Cymostrophia cresswelli, Eospirifer eastoni* and *Howellella* sp., whilst further east (localities F110, F104, A85) at Yea and Strath Creek the same stratigraphic horizon yields *Boucotia australis, B. loyolensis, B. withersi, Tyersella typica, Isorthis festiva, Leptostrophia alata, L. affinilata, Hysterolites lilydalensis,* and *Eospirifer eastoni* which are typical of the *loyolensis* zone at Lilydale.

In the vicinity of Eildon and Jamieson, the *loyolensis* zone occurs at isolated localities within the lower 1 000 m of the Norton Gully Sandstone (Bell 1961) where it is represented by a low diversity allochthonous fauna. The fauna includes *Boucotia loyolensis, B. australis, Leptostrophia affinilata, Hysterolites lilydalensis, Hipparionyx major, Notoleptaena undulifera* and *Acrospirifer* sp. nov. At Griffiths Quarry, Loyola, near Mansfield, twenty-three brachiopod species, many represented by single specimens, have been recognised from collections stored in the National Museum of Victoria. The species are found in pebbly mudstones and include: *Boucotia loyolensis, B. australis, Leptostrophia affinilata, L. alata, Cymostrophia euglyphoides, Nadiastrophia* cf. *superba, Mesodouvillina lilydalensis, Hipparionyx major, Notoleptaena otophera, N. undulifera, Leptaena* sp. nov., *'Parachonetes' baragwanathi, Maoristrophia* sp. nov., *M. keblei, Reeftonia alpha, Gypidula* sp. nov., *Eospirifer eastoni, Howellella* sp., *Hysterolites lilydalensis, Acrospirifer* sp. nov. and *Cyrtina* cf. *heteroclita gregale.* This greatly expands the previous known assemblage from Loyola, and all species listed are important in the correlation between Lilydale and Tabberabbera, Victoria, NSW and New Zealand.

The base of the *loyolensis* zone at Lilydale is about 1 700 m below the base of the Lilydale Limestone Member, which it has been argued elsewhere in this paper is 'early' Pragian in age. The plant-graptolite beds (the upper plant graptolite Horizon of Couper (1965)), which is interbedded with the *loyolensis* zone at Seymour, Yea and Flowerdale is also regarded as early Pragian (Garratt 1979). Likewise at Eildon, where the *loyolensis* zone overlies the Wilson Creek Shale (equivalent to the upper plant-graptolite Horizon of Yea) an 'early' Pragian age is suggested. The top of the *loyolensis* zone which probably coincides with the Loyola Limestone at Loyola contains *Eognathodus trilinearis* and *Polygnathus* sp. (Cooper 1973b), suggesting a late Pragian age. Thus on present evidence the *loyolensis* zone ranges from 'early' to 'late' Pragian.

OCCURRENCES OF BRACHIOPOD ASSEMBLAGE ZONES OUTSIDE THE MELBOURNE TROUGH

The *Aegiria thomasi* zone has not been recognised elsewhere in the Lachlan Fold Belt and this may reflect the scarcity of published work on Silurian brachiopod faunas in Australia.

The *plentiensis* zone may be present in the Yass Basin, New South Wales (Brown 1941), and the Dundas Trough, Tasmania. The Yarwood Siltstone Member of the Black Bog Shale (Link 1970) at Yass has yielded, amongst other species, *Hedeina bowningensis* and *Plectodonta bipartita* (identified from Australian Museum collections). This horizon is overlain by shales containing *Bohemograptus bohemicus* and *Linograptus posthumus posthumus* and was assigned to the late Ludlow by Link (1970). This suggests that the Yarwood Siltstone Member is 'mid' Ludlow in age and broadly correlates with the *plentiensis* zone of the Melbourne Trough. Further, the conodont fauna of the Yarwood Siltstone Member was correlated with that of the *latiolatus* zone by Link and Druce (1972).

The Florence Sandstone (Talent & Banks 1967) outcrops near Zeehan and Queenstown in the Dundas Trough, Tasmania. It has yielded a very similar fauna to that occurring in the *plentiensis* zone at Whittlesea and Upper Plenty. It includes *Hedeina denslineata*, Ambocoelidae gen. et sp. nov., *Isorthis* sp. nov., *Salopina* sp. nov. A, *Maoristrophia banksi* and *Leptostrophia plateia*. This list is based on collections from the National Museum of Victoria. The only other noteworthy species so far described from the Florence Sandstone are *Notoconchidium florencencis, Strophonella australiensis* and *Amphistrophia lyelli* (Gill 1950). *Maoristrophia* has been recorded from the underlying Austral Creek Siltstone at Princess River, Tasmania together with the late Wenlock graptolite *Monograptus vulgaris* (Talent & Banks 1967, p. 158). Even allowing for the apparent absence of *Notoparmella plentiensis* and *Notanoplia panifica* from the Tasmanian sequence, the *plentiensis* Assemblage Zone appears to represent most of the thickness of the Florence Sandstone, giving an approximate late early Ludlow age for the basal beds of the Florence Sandstone thereby confirming Philip's (1967, p. 918) correlation for this part of the Tasmanian sequence. The Skalian (= Pridolian) age given by Talent & Banks (1967, p. 152) for the same section is not accepted.

The recognition of the *janaea* zone outside the Melbourne Trough is yet to be determined but two possible areas occur in New South Wales - Manildra (Savage, 1968) and Bungonia (Jones *et al.* 1981). Near Manildra, New South Wales, Savage (1968) recorded an assemblage from near the top of the Fairhill Formation including *Dolerorthis* cf. *persculpta, Isorthis,* cf. *festiva, Howellella* cf. *scabra, Eospirifer parahentius* (synonym of E. *eastoni*), *Schizophoria* sp., *Spirigerina* cf. *supramarginalis* and *Plectodonta bipartita*. Savage was unable to assign this assemblage to a precise horizon of the Lower Devonian, and the overlying Maradana Shale contains an assemblage which clearly belongs to the *australis* zone. The assemblage from the Fairhill Formation indicates an age ranging from *janaea* to *australis* zone. Certainly *Eospirifer eastoni* and *Schizophoria* sp. strongly support a Devonian age for the assemblage. Strusz (1972, p. 442) drew attention to the absence of *Notoconchidium* in the Fairhill Formation, and concluded that the top of the formation was significantly above the base of the Devonian. However the distribution of *Notoconchidium* in the Melbourne Trough is strongly influenced by environment and its absence here may be related to water depth and/or lithofacies rather than age.

The *australis* zone is widely recognised in New South Wales and Tasmania. The fauna recorded and described from the Bell Shale (above the so-called "transition beds") of Tasmania by Gill (1948, 1950), and Talent & Banks (1967), includes *Notanoplia pherista, Australocoelia polyspera, Mesodouvillina lilydalensis, Maoristrophia keblei* and *Notoleptaena otophera. Boucotia australis* is apparently absent from the Bell Shale Assemblage. In New South Wales the *australis* zone is found in the Mullamuddy Formation at Mudgee, the Waterbeach Formation at Limekilns and the Maradana Shale at Manildra. From the Mallamuddy Formation, Wright (1967b), Wright *in* Strusz (1972) and Wright (1978, oral communication) recorded a suite of brachiopods including *Dolerorthis* cf. *persculpta, Strophonella* sp., *Gypidula* sp., *Spirigerina supramarginalis, Crytina* sp., *Hysterolites* and *Cyrtinopsis cooperi*, and is indicative of the *australis* zone. The Waterbeach Formation has yielded forms such as *Dolerorthis* sp., *Schizophoria* sp., *Boucotia australis, Eospirifer eastoni* and *Spirigerina supramarginalis* (Wright, 1967b). From the Maradana Shale of Manildra, New South Wales, Savage (1974) described *Skenidioides* sp., *Dolerorthis* sp., *Resserella elegantuloides, Dalejina* aff. *frequens, Muriferella* sp., *Mesodouvillina* cf. *limbinura, Leptostrophia affinilata, Notanoplia pherista, Gypidula* cf. *victoriae, Cyrtinopsis cooperi, Quadrithyris* cf. *robusta, Cyrtina* sp., *Spirigerina supramarginalis* and *Leptocoelia*, indicative of at least the *australis* zone. None of these four species occur beneath the *australis* zone in Victoria. The other species described by Savage are either long-ranging or not recorded from Victoria. Strusz (1972) recorded a brachiopod fauna from low in the Garra formation at Wellington including *Boucotia australis, Cymostrophia stephani, Isorthis festiva, Notoleptaena* cf. *otophera, Muriferella* cf. *punctata* and an *australis* zone is suggested. The *loyolensis* zone marks the top of the Yeringian fauna at Lilydale, Loyola and Tabberabbera, where it is found in the Dead Bull and Kilgower Members of the Tabberabbera Formation at Tabberabbera. The faunal information is provided by Talent (1963) and Talent (1972).

LILYDALE	LOYOLA	TABBERABBERA
Boucotia loyolensis	*B. loyolensis*	
B. australis	*B. australis*	
Plectodonta bipartita		*P. bipartita*
Isorthis allani	*Reeftonia alpha*	*R. alpha*
Schizophoria sp. nov. A		*Schizophoria* sp.

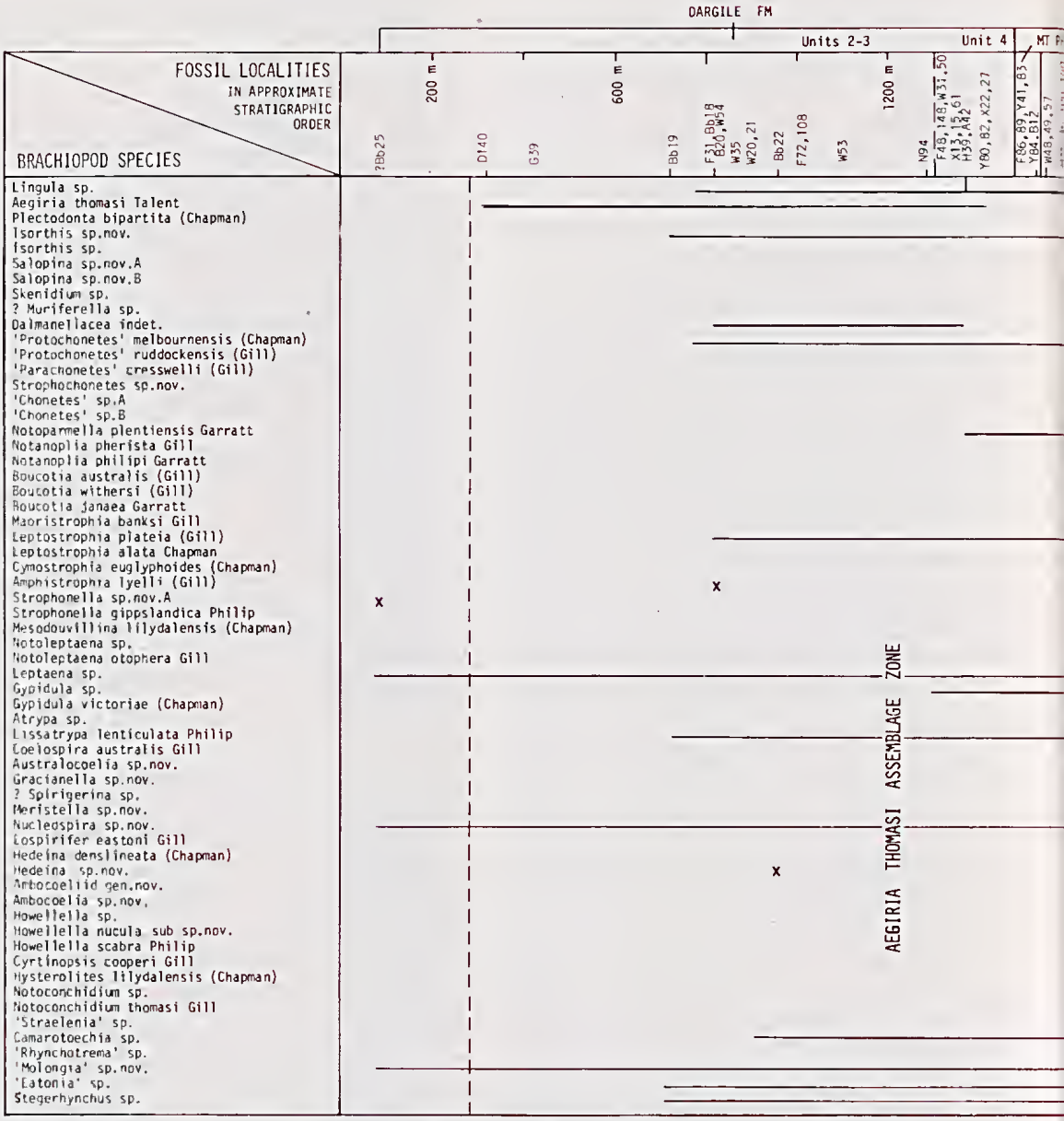

Fig. 6—Range chart of brachiopod species of the Kinglake-Whittlesea district, Victoria. The continuous horizontal lines intersect the known vertical range of the species in the area. The localities may or may not contain all the species indicated. The data on the distribution of brachiopods and assemblages at each locality is available from the author. The collections are stored in the National Museum of Victoria and the lists are prepared from collections made by A. Selwyn, N. Taylor, J. Jutson, R. Withers, G. Williams, E. Gill, T. Daragh and the author.

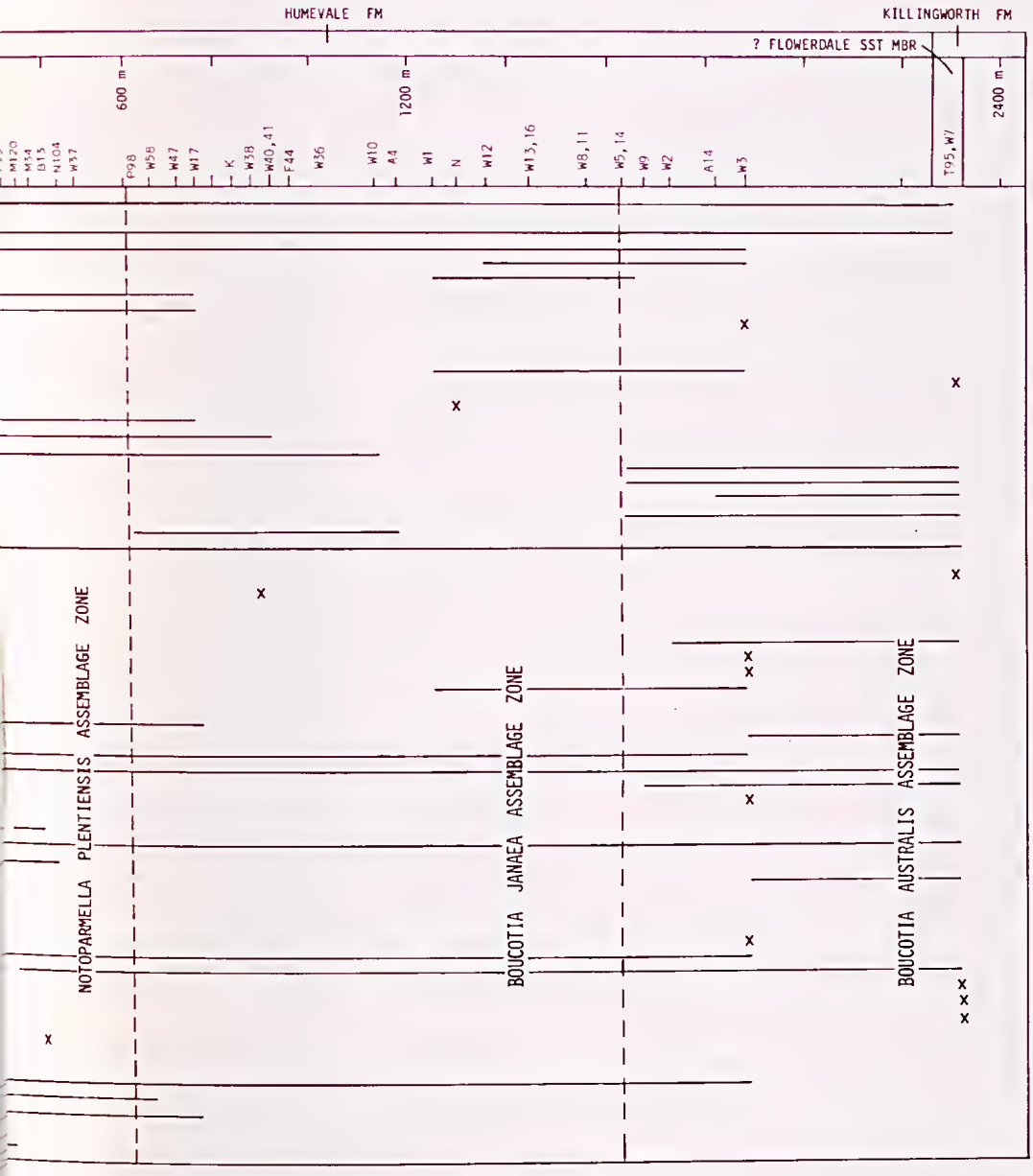

Fig. 6—(*continued*)

Fig. 7—Range chart of brachiopod species of the Heathcote district, Victoria. The continuous horizontal lines represent the known vertical range of the species in the area. The localities may or may not contain all the species indicated. The data on the distribution of brachiopods and assemblages at each locality is derived from Talent (1965a) and from recent collections made by John Neil, Bendigo.

Muriferella sp.		*Muriferella punctata*
'Protochonetes' baragwanathi	*'P.' baragwanathi*	*'P.' baragwanathi*
Leptostrophia alata	*L. alata*	
L. affinilata	*L. affinilata*	*L. affinilata*
Maoristrophia keblei	*M. keblei*	
Cymostrophia euglyphoides	*C. euglyphoides*	*C. euglyphoides*
Nadiastrophia sp.	*N.* cf. *superba*	*N. superba*
Notoleptaena otophera	*N. otophera*	
	N. undulifera	*N. undulifera*
Hipparionyx major	*H. major*	*H. major*
Mesodouvillina lilydalensis	*M. lilydalensis*	
Gypidula sp. nov.	*G.* sp. nov.	*G. vultura*
Lissatrypa lenticulata		*L. lenticulata*
'Spinatrypa' fimbriata	*'S.' fimbriata*	*'S.' perflabellata*
Eospirifer eastoni	*E. eastoni*	*E. eastoni*
Howellella sp. nov.	*Howellella* sp.	*H. textilis*
Spiriferide gen. nov.	Spiriferide gen. nov.	
Acrospirifer sp. nov.	*Acrospirifer* sp. nov.	
Cyrtinopsis cooperi		*C. cooperi*
Hysterolites lilydalensis	*H. lilydalensis*	*H. lilydalensis*
Cyrtina cf. *heteroclita gregale*	*C.* cf. *heteroclita gregale*	*C. heteroclita gregale*
Uncinulus sp. nov. A.		*U. calathuscus*
Nucleospira sp. nov.		*N. bellornata*
? Eurekaspirifer sp.		*Adolfia glypta*

It is apparent from the above lists that the fauna of the Dead Bull and Kilgower Members at Tabberabbera contain many elements common to Lilydale and Loyola. The differences may be due to facies or to age. Figure 3 shows that most of the faunas of the Dead Bull and Kilgower Members are younger than those from Loyola. An even more marked faunal change occurs between the Kilgower and Roaring Mag Members where new elements such as *Buchanathyris westoni, B. pulchra, B.* ? sp. A., *'Hysterolites' tritus, H.* sp. C. and *H.* sp. E. occur in the Roaring Mag Member; such an assemblage has affinities with the Buchan Caves Limestone and Bell Point Limestone assemblages which are dominated by *Spinella, Buchanathyris, Atrypa, Nadiastrophia, Cymostrophia,* corals and gastropods (Talent 1965b, Talent & Banks 1967, Strusz 1972), and probably warrant delineation of one, or two assemblage zones. Sherwin's (1980) *Spinella* 'Zone' described from Cobar warrants future attention. However, more work is necessary on the biostratigraphy of these 'late' Pragian-Zlichovian brachiopod faunas of southeast Australia. At present the *loyolensis* zone is considered to extend up into the Kilgower Member of the Tabberabbera Formation. In the Queen's Pinch region of New South Wales, Wright (1966) reported the occurrence of *Nadiastrophia* cf. *superba, Muriferella punctata* and *Leptostrophia affinilata* from the middle of the Mullamuddy Formation: *Nadiastrophia* cf. *superba* and *Leptostrophia affinilata* from the Taylors Hill Formation; and *Dolerorthis* cf. *persculpta, Cyrtinopsis cooperi, Muriferella punctata* and *Nadiastrophia* cf. *superba* from the Ingleburn Formation. *Leptostrophia affinilata, Crytinopsis cooperi, Ivanothyris, Adolfia* and *Dolerorthis* cf. *perscuplta* are also known from the Sutchers Creek Formation. All these assemblages suggest correlation with the *loyolensis* zone ("Tabberabberan Fauna"), the contacts between the various formations are fault bounded (Strusz, 1972, correlation chart), and may be coeval, depending upon the range of *Nadiastrophia* cf. *superba* and *Muriferella punctata.*

CORRELATION OF BRACHIOPOD ASSEMBLAGE ZONES OUTSIDE OF AUSTRALIA

Of the assemblage zones described herein, only the Devonian zones (*janaea, australis* and *loyolensis* zones) are important in correlation outside Australia. The *janaea* zone is discussed under the Siluro-Devonian Boundary. The base of the *australis* zone is considered to be of 'late' rather than 'early' Lochkovian age. The following forms appearing at or close to the base of the *australis* zone have value for correlation (those marked with an asterisk are of local value only), *Boucotia australis*, Notanoplia philipi*, Hysterolites lilydalensis, Cyrtinopsis cooperi*, Muriferella* sp., *Cymostrophia creswelli**, and *Uncinulus* sp. nov. *A**. Solle (1963) concluded from a study of *Hysterolites* that the top of the Ober Graptolithenschiefer in Thuringia is within the middle to middle upper Siegenian. Strusz (1972, p. 428) noted that the *hercynicus* zone ("Upper" Lochkovian) extends to the top of the Ober Graptolithenschiefer. It implies that *Hysterolites* arose in central Europe in the "late" Lochkov. Erben & Zagora (1967, p. 61) also noted that *Hysterolites* appeared in the "late" Lochkov in the Hercynian facies in Germany, and ranges through to the upper Emsian (Jahnke 1971). The appearance of *Hysterolites* at Lilydale, Heathcote and Kinglake is considered to indicate a "late" Lochkov age. At Lilydale, the base of the succeeding *loyolensis* zone contains Pragian brachiopod assemblages in an interrelationship with the *thomasi, acuaria* zone and *sulcatus sulcatus* zones ranging up to at least the *sulcatus* n. sub. sp. zone of the 'late' Pragian.

The appearance of local elements such as *Cyrtinopsis cooperi, Boucotia australis, Notanoplia philipi* and *Uncinulus* sp. nov. A are considered indicative of the 'late'

Lochkov in southeastern Australia. The rare occurrence of *Muriferella* in the *australis* zone at Lilydale, Kinglake and Manildra also suggest a 'late' Lochkov age; it is indicative of the 'upper' Lochkov *Spirigerina supramarginalis* Unit at Royal Creek, Yukon (Lenz, 1977a, b).

From New Zealand the Baton River fauna (Shirley 1938, Wright 1967a), and the Reefton Fauna (Allan 1935, 1947, Boucot *et al.* 1963, Boucot *et al.* 1966, Gill *et al.* 1966), include elements which are common to the *loyolensis* zone of the Victorian sequence. However, both the Baton River and Reefton lists must be considered provisional, only those forms previously published are given. The faunas are in need of revision and include forms yet to be described.

LILYDALE	BATON RIVER	REEFTON
Isorthis allani	*I. allani*	*Reeftonia marwicki*
Fascicostella sp. nov.	*F. gervillei*	
Schizophoria sp. nov. A.	*S. provulvaria*	
Leptostrophia affinilata	*L. explanata*	*L. reeftonensis*
M. lilydalensis	*Mesodouvillina* sp.	
C. euglyphoides	*Cymostrophia stephani*	
H. major	*Hipparionyx minor*	
E. eastoni	*Eospirifer eastoni*	*"Hedeina" bensoni*
Cyrtinopsis cooperi	*C. cooperi*	
Acrospirifer sp. nov.	*A. 'arduennensis'*	*A. coxi*
C. cf. *heteroclita gregale*	*Cyrtina heteroclita*	
Spiriferide gen. nov.		Spiriferide gen. nov.
Hysterolites lilydalensis	*H.* cf. *subspeciosus*	
Maoristrophia keblei		*M. neozelanica*

As can be seen from the faunal lists there are more species in common between Lilydale and Baton River than between Lilydale and Reefton, although *Reeftonia alpha* occurs at Loyola and Tabberabbera. The Baton River fauna has been assigned to the Siegenian (Shirley 1938, Boucot *et al.* 1969, p. 13) by correlation of the Baton River Beds with the Devonian of Europe (Shirley, 1938) and with Seigenian to early Emsian horizons at Lilydale and Tabberabbera (Boucot *et al.* 1969, p. 13). According to Boucot *et al.* the Reefton Beds are younger (early Emsian), thereby explaining the faunal differences between Baton River (Tasman Subprovince) and Reefton (New Zealand Subprovince). Equally, in view of the differences in sediment types between Reefton and Baton River (Wright 1967a), environmental factors such as water depth, current activity and bottom sediment type, may have influenced the composition of the benthos. As yet no reliable published data on the age or faunal community relationships of the New Zealand Devonian sequences are known. They seem to correlate with the *loyolensis* zone; they are certainly older than the Buchanian fauna ('late' Pragian).

DISCUSSION OF THE SILURIAN-DEVONIAN BOUNDARY IN THE MELBOURNE TROUGH

The base of the *janaea* zone is believed to coincide approximately with the Silurian-Devonian boundary in the Melbourne Trough. Because of the absence of Pridoli and Lochkov graptolites and conodonts in the Melbourne Trough, discrimination of the Silurian-Devonian boundary, now accepted as being the base of the *uniformis* zone (McLaren 1977), must rest with the shelly fauna. The taxa which appear to be useful in delineating the base of the Devonian in Victoria include *Eospirifer eastoni, Cyrtina* sp. nov., *Boucotia janaea, Cymostrophia euglyphoides, Maoristroplia keblei, Leptostrophia alata, Schizophoria* sp. nov. A, and *Gypidula victoriae* of the *janaea* zone. In terms of world-wide distribution, *Cyrtina, Boucotia, Schizophoria* and *Cymostrophia* are essentially Devonian genera (but see Boucot 1977). Berdan *et al.* (1969) and Johnson (1966) note that *Cyrtina* is unknown from pre-Devonian strata. The record of a single specimen of *Cyrtina* from 25 m below the base of the *uniformis* zone in the Roberts Mountain Formation of the Birch Creek Section, Nevada, by Johnson, *et al.* (1973) has yet to be authenticated. Boucot's (1977) listing of *Cyrtina* from the Pridolian of the Cordilleran Province is probably based on this Nevada occurrence. No authenticated pre-Devonian occurrence of *Cymostrophia* is known. *Schizophoria* has been recorded from the Pridoli of the Cordilleran Province (Boucot 1977, p. 312, Lenz 1977a, p. 48) and as a rare genus in the Bohemian Province of central Asia (Nikiforova 1937, p. 7). In all other faunal provinces it appears at the base of the Devonian. *Boucotia* is not known in the Tasman subprovince from any zone earlier than the *janaea* zone.

Eospirifer eastoni, Leptostrophia alata and *Maoristrophia keblei* all appear at or close to the base of the *janaea* zone in the Melbourne Trough. The record of *Eospirifer* from the Pridolian of the Tasman subprovince by Boucot (1977, p. 314) rests on the yet to be confirmed age of the Mallee Tank Beds of the Cobar Region, New South Wales (Iten & Carter 1951), it is not known whether this species is *E. eastoni* or not.

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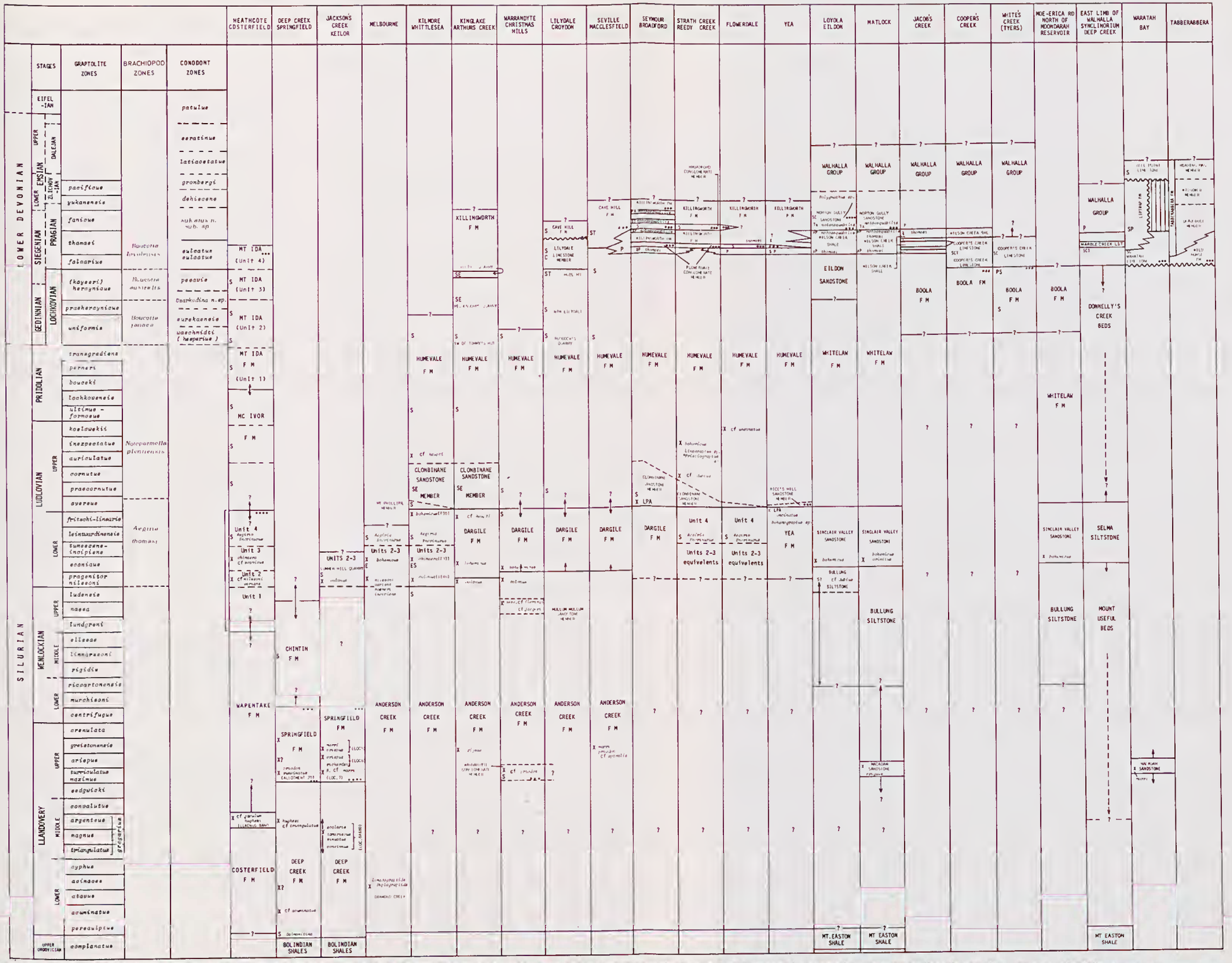

X = graptolites; P = plants; LPA = Lower Plant Assemblage; T = Styliolinids; E = echinoderms; C = conodonts; S = shelly fauna; ~ = unconformity; ... = conglomerate horizons

Fig. 2 – Correlation of Siluro-Devonian sequences of the Melbourne Trough and Tabberabbera Victoria. Note the proposed relationship between the graptolite, brachiopod and conodont zones in the left hand side of the chart.